

Circuit class therapy can provide a fitness training stimulus for adults with severe traumatic brain injury: a randomised trial within an observational study

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Questions: Can circuit class therapy provide sufficient exercise dosage (at least 20 minutes at $\geq 50\%$ heart rate reserve or total caloric expenditure ≥ 300 kilocalories) to induce a cardiorespiratory fitness effect in adults with traumatic brain injury? Can feedback from heart rate monitors influence exercise intensity? **Design:** Randomised controlled trial within an observational study. **Participants:** Fifty-three people with severe traumatic brain injury, of whom 40 progressed into the trial. **Intervention:** All participants undertook circuit class therapy. Participants allocated to the experimental group received exercise intensity feedback from a heart rate monitor and the control group received no feedback. **Outcome measures:** Proportion of participants exercising at $\geq 50\%$ heart rate reserve for at least 20 minutes or expending ≥ 300 kilocalories during circuit class therapy. The primary outcome measure for the trial was the time spent in the heart rate training zone (ie, at $\geq 50\%$ heart rate reserve) during the intervention and re-assessment periods. **Results:** Circuit class therapy provided sufficient cardiorespiratory exercise dosage for 28% (95% CI 18 to 42) of the cohort according to the heart rate reserve criteria and 62% (95% CI 49 to 74) according to the caloric criteria. Feedback did not increase the time in the training zone during the intervention (mean difference 4.8 minutes, 95% CI -1.4 to 10.9) or re-assessment (1.9 minutes, -4.4 to 8.3) periods. **Conclusion:** The low intensity, long duration structure of circuit class therapy can provide sufficient exercise dosage for a fitness training effect for 62% of people with traumatic brain injury. Feedback from heart rate monitors does not necessarily influence exercise intensity. **Trial registration:** ACTRN12607000522415. [Hassett LM, Moseley AM, Whiteside B, Barry S, Jones T (2012) Circuit class therapy can provide a fitness training stimulus for adults with severe traumatic brain injury: a randomised trial within an observational study. *Journal of Physiotherapy* 58: 105–112]

Key words: Brain Injuries, Physiotherapy (Specialty), Exercise, Heart rate, Feedback

Introduction

Cardiorespiratory deconditioning is a common secondary physical impairment experienced by people who have sustained a traumatic brain injury, with measured peak oxygen uptake ranging from 16.5 mL/kg/min (Bhambhani et al 2005) to 36.5 mL/kg/min (Hassett et al 2007). Comparing these measured values to age-matched able-bodied data from the American College of Sports Medicine (American College of Sports Medicine 2000), people with traumatic brain injury are rated as below average fitness (ie, below the 30th percentile fitness level). Deconditioning results from prolonged bed rest (Saltin et al 1968) and inactivity during initial hospitalisation for an extended period of time, and is further perpetuated by psychosocial consequences of the injury such as lack of motivation and initiative (Chervinsky et al 1998, Satz et al 1998) and depression (Fann et al 2003). Cardiorespiratory deconditioning therefore needs to be addressed as part of the rehabilitation program for people with traumatic brain injury.

The American College of Sports Medicine has established guidelines for the recommended exercise dosage to induce a cardiorespiratory fitness training effect. The guidelines at the time this project was commenced recommended an exercise frequency three to five times per week, at an intensity of 40 or 50% to 85% heart rate reserve, duration of ≥ 20 minutes, and participating in an exercise mode that uses large muscle groups in a rhythmical and continuous nature (Swain and Leutholtz 2007). The American College of

Sports Medicine has also established guidelines for persons with chronic diseases and disabilities including people with traumatic brain injury and stroke (Palmer-McLean and Harbst 2009), in which the exercise dosage is prescribed based on caloric expenditure. This is determined from the 'relative exercise dosage', which combines the intensity and duration of exercise. That is, you can have the same caloric expenditure from high intensity, short duration exercise as you can from low intensity, long duration exercise. The recommended caloric expenditure per exercise session for people with traumatic brain injury and stroke is ≥ 300 kilocalories (kcal) (Palmer-McLean and Harbst 2009).

What is already known on this topic:

Cardiorespiratory deconditioning is common among people who have sustained a traumatic brain injury. Circuit classes with functional exercises can provide rehabilitation and, if the intensity is sufficient, could provide a cardiorespiratory fitness training effect.

What this study adds: Circuit class therapy provides a sufficient dose of exercise to improve cardiorespiratory fitness in some people with traumatic brain injury. Among those who did not achieve a sufficient training stimulus during the class, the provision of continuous feedback about whether their heart rate was in the training zone did not significantly improve the intensity of exercise performed.

The physiological intensity of routine physiotherapy intervention in rehabilitation has been examined in two observational studies of people after stroke (Kuys et al 2006, MacKay-Lyons and Makrides 2002). Both studies conclude that routine physiotherapy intervention does not meet the minimum intensity to induce a cardiorespiratory fitness training effect as defined by the American College of Sports Medicine. This has also been investigated in people with moderate to severe traumatic brain injury (Bhambhani et al 2005), with peak cardiorespiratory responses not changing during five weeks of participation in a routine neurological rehabilitation program. These results would indicate that in order for cardiorespiratory deconditioning to be addressed in rehabilitation, either specific cardiorespiratory fitness interventions need to be incorporated, or the way rehabilitation is structured needs to be modified.

Group circuit class therapy was introduced into rehabilitation as a means to increase patient practice, as an efficient way to provide therapy (Carr and Shepherd 1998, English and Hillier 2010), and has been shown to improve mobility in people after stroke (English and Hillier 2010). In the rehabilitation context, circuit classes typically involve one to two hours of functional exercise (eg, standing up from sitting, walking, stair climbing) three to five times per week (English and Hillier 2010). Patients rotate around a series of exercise stations that can be adapted and progressed to meet the needs of individual patients. This group circuit class therapy appears to be an appropriate exercise mode and of sufficient frequency and duration to meet American College of Sports Medicine guidelines for cardiorespiratory fitness training. If the intensity is sufficient, circuit class therapy may be feasible to provide sufficient exercise dosage for a cardiorespiratory fitness training effect in people with traumatic brain injury.

The research questions were:

1. Can circuit class therapy provide sufficient exercise dosage (at least 20 minutes at $\geq 50\%$ heart rate reserve or total caloric expenditure ≥ 300 kcal) to induce a cardiorespiratory fitness training effect in adults with severe traumatic brain injury?
2. Can adults with severe traumatic brain injury who cannot achieve sufficient exercise intensity to induce a cardiorespiratory fitness training effect use feedback from heart rate monitors to increase their intensity of exercise?

Method

Design

To determine if circuit class therapy provides sufficient exercise dosage to induce a cardiorespiratory fitness training effect (ie, Question 1), a single-centre observational study was conducted. Patients who were screened by the investigators and fulfilled the eligibility criteria were invited to participate by their treating physiotherapist. All participants had exercise data recorded by a heart rate monitor for three classes in Week 1. The exercise data were then averaged over the baseline period to determine if the participant could achieve the minimum criteria required to induce a cardiorespiratory fitness training effect. Participants received no feedback regarding their intensity of exercise during these classes because the digital readout from the heart rate monitor was covered and the sound muted.

To determine if feedback from heart rate monitors can increase exercise intensity (ie, Question 2), a single-centre parallel-group randomised controlled trial was conducted. Participants who failed to reach the minimum criteria designated for a fitness training effect (at least 20 minutes at $\geq 50\%$ heart rate reserve) (Swain and Leutholtz 2007) during the baseline period progressed into the randomised controlled trial, as presented in Figure 1. In the initial trial registration (ACTRN12607000522415), the criterion was at least 30 minutes $\geq 50\%$ to 70% heart rate reserve. This was adjusted before commencing the trial to match the American College of Sports Medicine guidelines (Swain and Leutholtz 2007) more closely. The upper limit of the heart rate training zone was not included because the focus of this trial was investigating whether people could exercise to at least the minimum criteria for a fitness training stimulus. We were not concerned if people in this low risk population spent short periods above 85% heart rate reserve and wanted this included as part of their effective training time. A randomisation schedule was prepared from a computer-generated list of random numbers by a person independent of the recruitment process. Sealed, sequentially numbered, opaque envelopes were prepared for the site. The investigator selected the next envelope to determine allocation to either the experimental group receiving feedback from the heart rate monitor, or to the control group who continued to receive no feedback from the heart rate monitor. The intervention period lasted two weeks (six classes) and then both groups returned to the original condition (heart rate monitor covered and sound muted) for the re-assessment period (three classes). The assessor was not blinded to group allocation as the only outcome data collected was from the heart rate monitor; this objective measure of exercise intensity has low susceptibility to bias.

Participants, therapists, centre

Participants were recruited from consecutive patients admitted to circuit class therapy between October 2007 and April 2011 from a brain injury rehabilitation unit in Sydney, Australia. This is one of three Sydney-based units within the Brain Injury Rehabilitation Program of New South Wales and provides a multidisciplinary rehabilitation program for adults who have sustained predominantly traumatic brain injuries. Patients were invited to participate if they fulfilled the following eligibility criteria: aged between 15 and 65 years; sustained a very severe or extremely severe traumatic brain injury (ie, post-traumatic amnesia period > 1 week assessed using the Modified Oxford Post Traumatic Amnesia Scale (Pfaff and Tate 2004); emerged from post-traumatic amnesia; currently attending or eligible to attend the circuit class at least twice per week and it was anticipated that they would be attending the class for at least four weeks. Patients were excluded from participating if their treating rehabilitation physician and the lead investigator clinically determined they had: a concurrent medical condition for which moderate to high intensity exercise was contraindicated; behaviour problems not suitable for a group environment; or insufficient English or language skills to understand verbal instruction and feedback. Circuit class therapy was provided by physiotherapy staff of the brain injury rehabilitation unit, including physiotherapy undergraduate students, physiotherapy assistants, and qualified physiotherapists ranging in experience from one year to > 15 years of clinical experience.

Intervention

The circuit class that we investigated has been running at the rehabilitation unit since 2000. Circuit class therapy is implemented for one hour, three times per week, and is attended by patients from inpatient, transitional living, and community-based programs. Patients rotate around a circuit of 10 exercise stations, spending four minutes at each station. After completing all stations they undertake abdominal exercises and a competitive six-minute walk as a group. The circuit class is set to music, with the song changing every four minutes to signal when to move to the next exercise. There are no rest periods between exercises.

The circuit class is supervised by two to four physiotherapy staff, depending on the number and individual needs of the patients attending. On average eight patients attend each class, but it has capacity for up to 14 patients. In order to make the class as inclusive as possible, each station has an option of four or five different exercises depending on each individual's current level of functioning. For example Station 1 ranges from basic standing balance exercises of stepping up to touch a step and stepping in different directions from the standing position, up to more difficult tasks such as balancing while performing fast hip flexion or jogging on a mini-tramp. The other nine stations include upper limb strengthening exercises (Stations 2 and 3), treadmill or 10-metre walking or jogging (Station 4), functional strengthening of the plantarflexor, lower limb extensor, and hip abductor muscle groups (Stations 5, 6, and 7), sit to stand (Station 8), obstacle walking or agility running (Station 9), and cycle ergometry (Station 10).

Before each participant attended the first class, their heart rate training zone was calculated and all their demographic data (ie, age, weight, height, sex) and heart rate training zone were entered into a heart rate monitor (Polar F4TM^a) designated to them for the length of their participation in the study. Heart rate training zone was calculated as $\geq 50\%$ heart rate reserve using the Karvonen equation (American College of Sports Medicine 1998): heart rate training zone $\geq 0.5 \times ([220 - \text{age in years}] - \text{resting heart rate}) + \text{resting heart rate}$. The resting heart rate was measured in the early morning (if possible) by the treating physiotherapist using the heart rate monitor to record the average heart rate in the last 2 minutes of a 5-minute seated rest period. The heart rate monitors were used to collect outcome data, but the digital readout was covered and sound muted for the baseline and re-assessment periods. All heart rate monitors were serviced yearly as per manufacturer recommendations for the course of the study.

Participants in the experimental group had their heart rate monitor uncovered and the sound turned on so that it beeped if they were not in their heart rate training zone during the intervention period. Their treating physiotherapist explained what heart rate they needed to exercise above, and the fact that they needed to try to keep the sound off as much as possible by exercising at sufficient exercise intensity. Physiotherapy staff who were supervising the class used the information from the heart rate monitor to provide encouragement regarding the intensity of exercise and to progress exercises where possible (eg, lowering the height of the chair for the sit-to-stand station).

Participants in the control group continued to attend the circuit class with the heart rate monitor covered and the

sound muted. Physiotherapy staff supervising the class continued to encourage and progress exercises as they deemed appropriate as per standard protocol of the circuit class.

Outcome measures

All participants wore a heart rate monitor for each circuit class. The heart rate monitor recorded the following data: time spent in heart rate training zone (ie, $\geq 50\%$ heart rate reserve), caloric expenditure (kcal), duration of exercise (minutes), and average heart rate (beats per minute). These data were averaged over three classes for the observational study. For participants in the trial the data were also collected during the intervention period (six classes) and the re-assessment period (three classes).

For the observational study the primary outcome measure was the proportion of participants that met the minimum criteria for a cardiorespiratory fitness training effect (ie, at least 20 minutes at $\geq 50\%$ heart rate reserve or total caloric expenditure ≥ 300 kcal). The secondary outcome measures were time spent in heart rate training zone, the total caloric expenditure (kcal), the duration of exercise (minutes) and the average intensity of exercise (expressed as a percentage of heart rate reserve).

For the randomised controlled trial the primary outcome measure was the time spent in the heart rate training zone (ie, $\geq 50\%$ heart rate reserve) both during the intervention period and during the re-assessment period.

Data analysis

Sample size: An *a priori* power analysis indicated that we needed to recruit 20 participants to each group (40 in total) for the randomised controlled trial. This calculation assumed an alpha of 0.05, beta of 0.2, a standard deviation of 37% total time spent in the training zone, taken from pilot data and traumatic brain injury only data from another study (Bateman et al 2001), and a smallest clinically important between-group difference of 33% total time spent in the heart rate training zone. From our pilot data we anticipated that we would need to recruit approximately 107 participants in total to obtain the 40 participants for the randomised controlled trial.

Statistical analysis: Data analysis was carried out according to a pre-established analysis plan. To determine whether a circuit class can provide sufficient exercise dosage to induce a cardiorespiratory fitness training effect in adults with severe traumatic brain injury (ie, Question 1), the proportion of participants achieving $\geq 50\%$ heart rate reserve for at least 20 minutes and the proportion of people expending ≥ 300 kcal were calculated. Confidence intervals for the proportions were computed using the Wilson score method (Newcombe 1998). Means and standard deviations were also calculated for time spent in the heart rate training zone, caloric expenditure, duration of exercise, and average percentage of heart rate reserve (intensity of exercise). In addition, to investigate the within-subject variability the mean, minimum, and maximum time in the heart rate training zone was plotted for each participant who had completed two or three classes at baseline.

To determine whether adults with severe traumatic brain injury can use feedback from heart rate monitors to increase their intensity of exercise (ie, Question 2), analysis

was completed on an intention-to-treat basis. To deal with missing data, intervention and re-assessment missing data had the baseline value carried forward. Student's t-tests were used to compare groups during the intervention period (average of six classes) and during the re-assessment period (average of three classes) for the primary outcome measure of time spent in the heart rate training zone.

Results

Flow of participants through the study

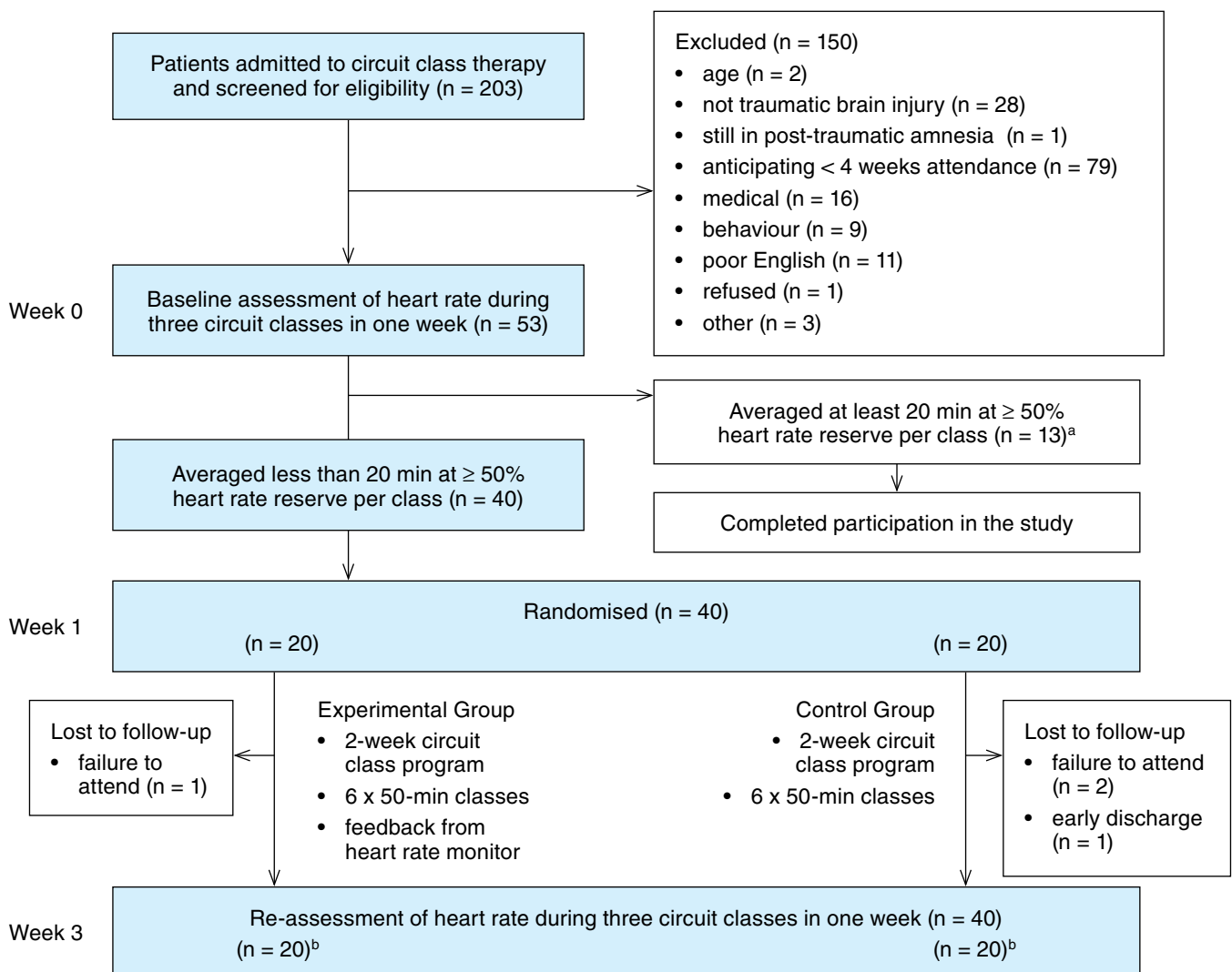
The flow of participants through the study is presented in Figure 1. Participants were recruited to the observational study until 40 participants met the criteria for the randomised controlled trial (ie, unable to spend at least 20 minutes at $\geq 50\%$ heart rate reserve). Of the 203 patients screened during the 3.5 years of recruitment, 146 (72%) were ineligible (mainly because their planned discharge date was less than four weeks after they were eligible for the study), one (0.5%) refused to participate, three (1.5%) were missed due to staff anticipating an early discharge date, and 53 (26%) were recruited. The baseline characteristics of participants are shown in Table 1.

Compliance with the study method

Two participants were wrongly recruited into the randomised controlled trial (ie, they met the minimum criteria); however they continued through the duration of the trial. All participants commenced the intervention to which they were originally allocated. Two participants in the experimental group completed fewer than four of the six classes scheduled in the protocol: one was recovering from cranioplasty, and one failed to attend. Three participants in the control group completed fewer than four of the classes, all due to failure to attend.

Exercise dosage of circuit class therapy

The circuit class provided a sufficient cardiorespiratory exercise dosage for 15/53 (28%, 95% CI 18 to 42) of the participants in the observational study according to the heart rate reserve criteria, and for 33/53 (62%, 95% CI 49 to 74) of participants according to the caloric expenditure criteria. Overall, participants spent < 20 mins in their heart rate training zone (mean 13 min, SD 14) but expended > 300 kcal (mean 377 kcal, SD 137), as presented in Table 2. The intensity of the circuit class was low (mean 34.3% heart rate reserve, SD 16.7) and the duration was long (mean 52.1 minutes, SD 3.1).



^a15 participants achieved sufficient exercise intensity to warrant exclusion from the randomised trial, however 2 were wrongly recruited into the trial. ^bParticipants who were lost to follow-up were analysed by carrying forward the last observation.

Figure 1. Design and flow of participants through the trial.

Table 1. Characteristics of participants.

Characteristic	Observational study	Randomised controlled trial	
		Exp	Con
	n = 53	n = 20	n = 20
Age (yr), mean (SD)	33 (14)	39 (17)	29 (11)
Gender, n (%) male	37 (70)	14 (70)	13 (65)
Time since injury (months), median (IQR)	3.7 (1.9 to 5.6)	3.7 (2.0 to 4.9)	3.1 (2.1 to 5.6)
Length post-traumatic amnesia (days), median (IQR)	48 (33 to 73) ^a	48 (32 to 77)	56 (35 to 78)
Injury severity, n (%)			
very severe	9 (17)	4 (20)	2 (10)
extremely severe	43 (81) ^a	16 (80)	18 (90)
Cause of injury, n (%)			
road traffic accidents	33 (62)	9 (45)	17 (85)
falls	11 (21)	7 (35)	0 (0)
acts of violence	5 (9)	2 (10)	1 (5)
other	4 (8)	2 (10)	2 (10)
Brain injury program, n (%)			
inpatient	32 (60)	9 (45)	16 (80)
transitional living unit	13 (25)	9 (45)	2 (10)
community-based	8 (15)	2 (10)	2 (10)
Body mass index (kg/m ²), mean (SD)	23.4 (3.4)	24.8 (3.3)	22.5 (2.7)
Body mass classification, n (%)			
underweight	2 (4)	0 (0)	1 (5)
normal	34 (64)	11 (55)	14 (70)
overweight	13 (25)	7 (35)	5 (25)
obese	4 (8)	2 (10)	0 (0)
Average waist circumference (cm), mean (SD)	83 (10)	84 (10)	81 (9)
Resting heart rate (bpm), mean (SD)	85 (13)	84 (11)	89 (15)

^an = 52 due to missing data

Figure 2 presents the within-subject variability between classes during the baseline period. Four out of 15 participants whose average time in the heart rate training zone was > 20 minutes had at least one class where they exercised below threshold for a cardiorespiratory fitness training effect. Conversely, 7 of 38 participants whose average time in the heart rate training zone was < 20 minutes had at least one class where they exercised above threshold for a cardiorespiratory fitness training effect. Twelve of the 53 participants were not able to spend any time in their heart rate training zone for any classes.

Effect of heart rate monitoring

There was no significant difference between the experimental group and the control group for the time spent in the heart rate training zone during the intervention period or during the re-assessment period. The mean time spent in the heart rate training zone during the intervention period was 10.9 minutes (SD 10.8) for the experimental group versus 6.1 minutes (SD 7.5) for the control group; mean difference 4.8 minutes (95% CI -1.4 to 10.9). The mean time spent in the heart rate training zone during the re-assessment period was 8.3 minutes (SD 8.9) for the experimental group versus

Table 2. Exercise data for baseline period averaged over three classes.

Outcome	Observational study	Randomised controlled trial	
		Exp	Con
	n = 53	n = 20	n = 20
Number of classes attended, mean (SD)	2.4 (0.5)	2.4 (0.5)	2.5 (0.6)
Exercise duration (min), mean (SD)	52 (3)	52 (2)	52 (4)
Exercise intensity (% heart rate reserve), mean (SD)	34 (17)	28 (12)	27 (12)
Time spent in heart rate training zone (min), mean (SD)	12.5 (13.7)	6.3 (7.6)	5.3 (5.8)
Kilocalories expended (kcal), mean (SD)	377 (137)	313 (103)	344 (106)

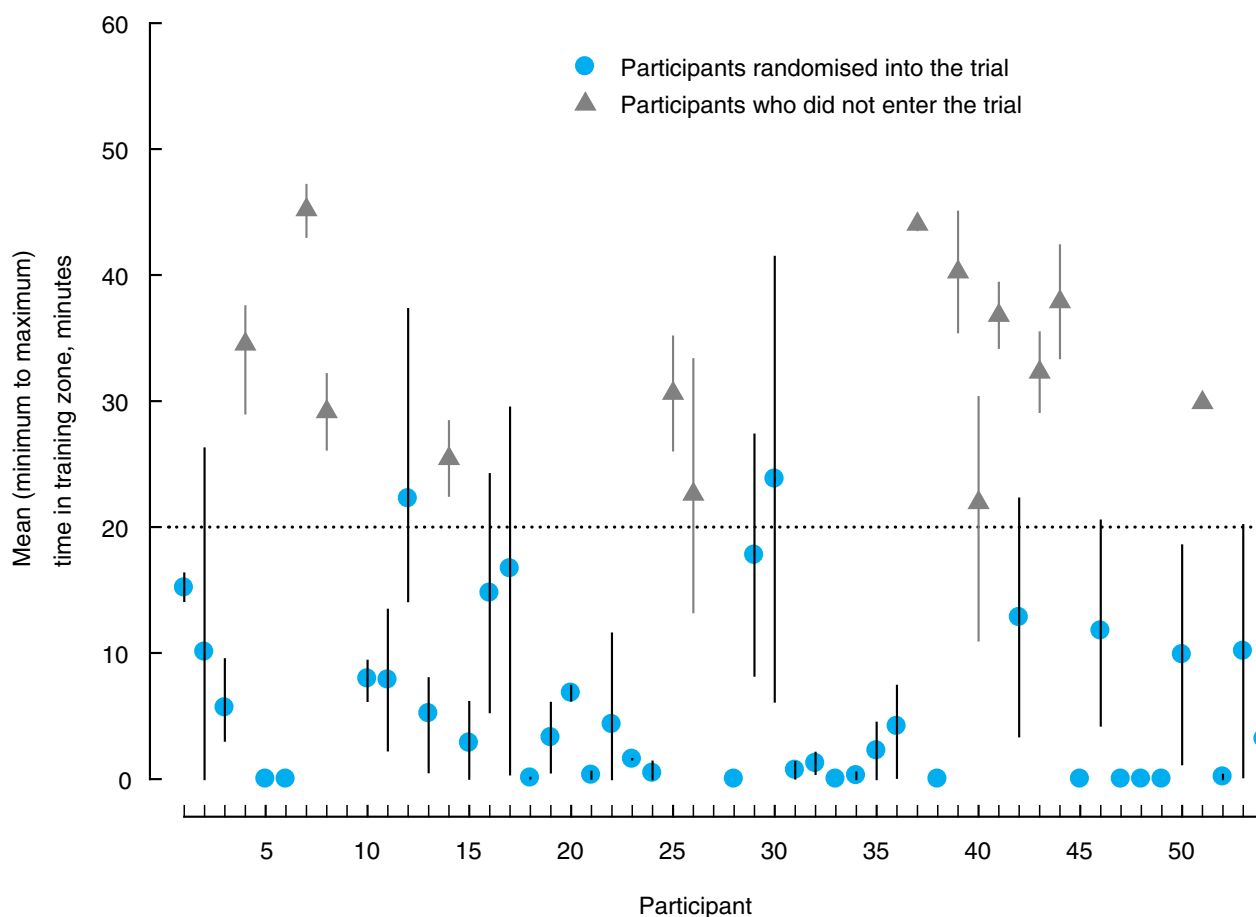


Figure 2. Within-subject variability of time spent in the heart rate training zone (minutes).

7.1 minutes (SD 9.4) for the control group; mean difference 1.9 minutes (95% CI -4.4 to 8.3), as presented in Figure 3. The smallest clinically important between-group difference chosen for this trial was 33% of the total exercise time spent in the heart rate training zone. The confidence intervals did not include this value during the intervention period (-2.8% to 21.9%) or the re-assessment period (-8.7% to 16.5%), thus the between-group differences are smaller than our initial estimates of the smallest clinically important difference.

Discussion

We confirmed that circuit class therapy is a low intensity, long duration type exercise. While only 28% of the cohort achieved the recommended intensity of exercise (ie, at least 20 minutes at $\geq 50\%$ heart rate reserve), the long duration of the exercise class meant that circuit class therapy did provide sufficient exercise dosage (≥ 300 kcal) for a cardiorespiratory fitness effect for 62% (95% CI 49 to 74%) of the cohort. The American College of Sports Medicine updated their exercise prescription guidelines in 2011 (American College of Sports Medicine 2011) and these new guidelines include the recommendation that low intensity, long duration exercise be used for deconditioned individuals. It is important to note that higher intensity exercise still provides greater fitness benefits (Swain 2005).

Feedback from heart rate monitors did not increase the intensity of exercise while receiving the feedback (during

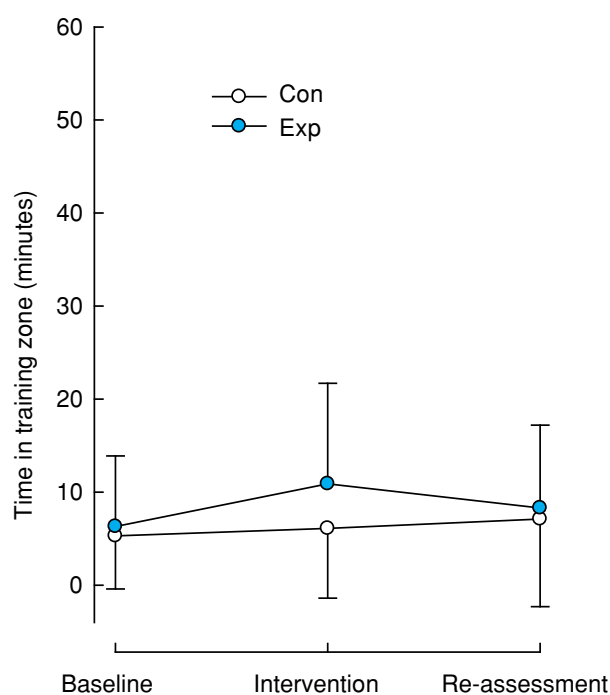


Figure 3. Mean (SD) time spent exercising in the heart rate training zone ($\geq 50\%$ heart rate reserve) for the experimental and control groups.

the intervention period) or after feedback was removed (during the re-assessment period), but there was a trend towards the experimental group spending more time in the heart rate training zone while receiving the feedback (mean difference 4.8 minutes, 95% CI -1.4 to 10.9). The use of augmented feedback from heart rate monitors has not previously been investigated in neurological populations, although its effectiveness has been shown in school-aged children (McManus et al 2008). It was observed that our participants understood the feedback quickly (usually within the first few stations in the first intervention class) and utilised the audio rather than the visual feedback (ie, they knew they had to exercise harder when the monitor sounded rather than remembering what heart rate they had to exercise above), and that staff utilised the feedback to guide progression of exercises. The neuromotor, cognitive, and behavioural impairments and significant deconditioning commonly seen in people with traumatic brain injury are barriers to participation in high intensity exercise. Perhaps the addition of verbal motivation and feedback from the treating physiotherapist is required to complement feedback from the heart rate monitor. The ability of different staff to motivate participants to exercise harder was not controlled in this study and could be the focus of future research.

Another interesting observation was the variability in exercise intensity displayed from participants from class-to-class (Figure 2). While some variability is expected, our within-subject variability was more extensive than the variability reported in studies involving able-bodied subjects (Lamberts and Lambert 2009). This difference could possibly be attributed to altered autonomic responses seen after traumatic brain injury (Katz-Leurer et al 2010), mood disturbances and motivational impairments (Chervinsky et al 1998, Fann et al 2003) which are both reactive to different settings and circumstances, and the environment of the class (eg, which physiotherapy staff were running the class, which patients were attending, what music was playing) (Dunton et al 2009, Yamashita et al 2006). This within-subject variability highlights another important reason to use heart rate monitors to record exercise dosage for each fitness training session: to confirm whether sufficient exercise dosage has been achieved and possibly extend the duration if the exercise intensity has been insufficient.

The evidence to support the effectiveness of fitness training to induce a cardiorespiratory fitness training effect in people with traumatic brain injury is unclear. A Cochrane systematic review (Hassett et al 2008) showed uncertainty in the effectiveness of fitness training in one trial (Bateman et al 2001) and a clear positive effect in the other (Driver et al 2004). It was hypothesised that the longer duration of exercise implemented in the second trial provided sufficient exercise dosage for a fitness training effect. The results from the observational phase of our study confirm the importance of long duration exercise to reach sufficient dosage for a fitness training stimulus in deconditioned populations. Further research is required to confirm whether fitness training prescribed and implemented at sufficient exercise dosage can improve cardiorespiratory fitness in people with traumatic brain injury.

This study has a few limitations. Circuit class therapy was investigated in one centre (a brain injury rehabilitation unit). While the content was similar to circuit class therapy

described in the literature (English and Hillier 2010), validation in a larger number of centres is required to confirm our findings. A blinded assessor was not used as it was anticipated that data collected from heart rate monitors has low susceptibility to bias, however there is still the risk that some bias existed when the data were transcribed from the monitor. The sample size calculation did not take into account the potential for drop-outs and set a very high threshold for the smallest clinically important difference (ie, 33% or ~17 minutes). Four participants dropped out of the trial and, although intention-to-treat analysis was conducted, this may have reduced the ability to detect a between-group difference. It is likely that a smaller between-group difference (eg, 8–10 minutes) would be clinically worthwhile, but further exploration of the smallest clinically important difference is warranted. Our data could be used to inform the power calculation of a larger trial.

In conclusion, the low intensity, long duration structure of circuit class therapy can provide sufficient exercise dosage for a cardiorespiratory fitness training effect in adults with traumatic brain injury. Feedback from heart rate monitors does not necessarily influence exercise intensity, although the results of this study would suggest the importance of using heart rate monitors to record all fitness training sessions to ensure sufficient exercise dosage is achieved. ■

Footnote: ^aPursuit Performance Pty Ltd, Level 1, 309 Pulteney Street, Adelaide SA 5000, Australia

Ethics: The Sydney South West Area Health Service Human Research Ethics Committee (Western zone) approved this study. All participants gave written informed consent before data collection began.

Competing interests: None declared.

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